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Stage 1 Disinfectants and Disinfection Byproducts Rule

When chlorine is added to water to kill pathogenic microorganisms it reacts with naturally occurring organic matter that is found in all source waters to form disinfection byproducts (DBPs). These byproducts have been demonstrated to have adverse health effects. Some of them can cause cancer. There is more and more evidence that some of them can cause reproductive problems or problems with the liver, kidneys or central nervous system. The two most prevalent DBPs are trihalomethanes (THMs) and haloacetic acids (HAAs).

Starting Jan. 1, 2004, all of Missouri's small surface water systems serving less than 10,000 people and all groundwater systems regardless of size that add chlorine to their water must begin complying with the new requirements of the Stage 1 disinfectants and disinfection byproducts rule (D/DBPR). The rule creates new maximum contaminant levels (MCLs) of 80 ug/L for THMs and 60 ug/L for HAAs. Stage 1 also creates a new standard called maximum residual disinfectant levels (MRDLs) that creates a maximum amount of chlorine, chloramine or chlorine dioxide that can be put in the distribution system. There is also a new treatment technique for surface water systems that requires them to operate in an enhanced coagulation or enhanced softening mode. Department of Natural Resources staff has been monitoring for DBPs in Missouri for sever-

al years and talking about the requirements of the Stage 1 D/DBPR so most people should have a pretty good understanding. This article will touch on the basics for a quick Stage 1 review.

Compliance with the THM and HAA MCLs will be based on a running annual average (RAA) calculation, computed at the end of each quarter. For example, most surface water systems will collect four samples the first quarter of 2004 for both THM and HAAs. Add all four THM sample results together and divide by four. This would be that system's THM quarterly average for the first quarter. Do the same for HAAs for the first quarter. Continue to calculate your quarterly averages each quarter, and by the end of December 2004 each system will have four quarterly averages for both THMs and HAAs. At this point an RAA can be calculated for 2004 by averaging the quarterly data collected over the course of the year. At the end of the first quarter of 2005 you would drop the first quarter of 2004 and average the four most recent quarters of data, and so on. This is what is meant by an RAA.

One thing that I want to point out about the compliance calculation for DBPs is that it might not take some of Missouri's surface water systems until the end of the year to exceed the MCLs. Because the compliance calculation is done at the end of each quarter, if a system's quarterly totals for THMs ever

exceeds 320 parts per billion (ppb) or if HAAs exceed 240 ppb (four times the MCLs) a system will be out of compliance at that time. Based on present data, this could happen for some of Missouri's systems by the end of the second or third quarter of 2004.

The Stage 1 D/DBPR also contains a new treatment technique that requires all surface water systems with conventional filtration plants to operate in an enhanced coagulation or enhanced softening mode to remove the naturally occurring organic matter that acts as precursors to disinfection byproducts. Total organic carbon (TOC) is the parameter that will be used to measure the precursors. Each system will have to remove a certain percentage of the TOC in their source every month based on the raw water alkalinity and the raw water TOC concentration. Lower alkalinity waters with high levels of TOC will have higher removal requirements. Each system must collect paired TOC samples each month; one of raw water before any treatment chemicals are added and one of treated water from combined filter effluent. The raw water alkalinity must also be measured at the same time and recorded on the chain of custody form in the sample kit provided by the state lab. A lot of people are forgetting the alkalinity part of this, but everyone must report it by writing it on the chain of custody. The

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alkalinity and raw water TOC are used to figure out how much TOC removal is required that month using the chart in Figure 1.

As one can see, the removal percentage might change every month if the source water quality changes. Once the required TOC removal percentage for a given month is known, you calculate how much TOC you have removed for that month. One way to calculate the removal is to use this formula: $1 - (\text{treated water TOC} / \text{raw water TOC}) \times 100$. The next step is to take your removal percentage from this calculation and divide

Figure 1

Step 1 Removal Percentages			
Source TOC (mg/L)	Source Alkalinity (mg/L)		
	0 to 60	>60 to 120	>120
>2.0 to 4.0	35	25	15
>4.0 to 8.0	45	35	25
>8.0	50	40	30

percentage removal requirements, they can apply to the state for what EPA calls alternate Step 2 removal requirements (this does not apply to systems that soften). The decision to take this step should be weighed carefully. Although it might result in a determination by the state that your source water is not always amenable to enhanced coagulation and lower TOC removal requirements, the process will consist of extensive bench and/or pilot scale testing and perhaps consulting engineering help. The state lab cannot provide the analytical support for this bench testing. The new Step 2 removal percentage can be applied retroactively (if you monitored for TOC in 2003) to keep your system in compliance, anytime during 2004. This is a very confusing part of this regulation, so if you get to this point Department of Natural Resources staff will assist you with the Step 2 decision and process.

A third way to comply with the precursor removal treatment technique is to use one of six alternate compliance criteria in lieu of meeting the Step 1 removals. Most of Missouri's surface water systems will not be able to take advantage of the alternate criteria very often, but a couple of them are mentioned here. If your source water TOC is less than 2 mg/L, you automatically comply for that month. The same thing applies if your treated water TOC is less than 2 mg/L. If your system might be able to use these criteria, be aware this is another option

to comply with the treatment technique, and you can mix and match the Step 1 removal calculations with the alternate compliance criteria month by month.

The Stage 1 D/DBPR also creates a new standard called maximum residual disinfectant levels (MRDLs) for three chemical disinfectants - chlorine, chloramines and chlorine dioxide. MRDLs will apply to all surface water systems and groundwater systems that add a disinfectant to any part of their treatment process. A MRDL is the maximum amount of disinfectant residual a water system can put in the distribution system. Compliance will be based on routine residual disinfectant sampling done by each system. For chlorine and chloramines the residual testing must be done at the same locations in the distribution system and at the same time that you do total coliform testing. The MRDL

for both chlorine and chloramine is 4 mg/L and compliance will be based on a running annual average of all the samples collected over the course of a year. For small surface water systems there is a spot to report MRDL data on the new disinfection and turbidity reporting form that you will have to start using to report in January 2004 under the interim enhanced surface water rule. Item number three in the distribution disinfection section will be an average of all residual readings for the month reported. Reporting forms will be provided to the groundwater systems.

If your system uses chlorine dioxide it has an MRDL of 0.8 mg/L and it has a degradation byproduct (chlorite) that has an MCL of 1 mg/L. Because only a handful of systems in Missouri use chlorine dioxide, this article is not going into a lot of detail on the requirements. It will suffice to say that compliance with the chlorine dioxide MRDL requires daily monitoring at the entry point to the distribution system, and follow-up monitoring in the distribution system the next day if chlorine dioxide is detected in any of the entry point sample. Monitoring for chlorite must also be done daily at the entry point and a three-sample set from distribution must be sent to a contract lab (paid for by the Department of Natural Resources) once a month.

Similar to the total coliform rule, every system that has to comply with the Stage 1 D/DBPR must prepare a monitoring plan. The plans must be completed by Jan. 31, 2004, and kept on file for review by the state. If a system serves more than 3,300 people, it must submit a copy to the Public Drinking Water Program no later than April 10, 2004. The plan must contain the following items:

1. A list of the locations where each system will be taking the THM and

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HAA samples and a schedule for when they will be taken. Indicate which location is the maximum residence time location.

2. A simple schematic drawing of your distribution system that shows where the sample locations are, where the plant is located, storage tanks and booster chlorination stations.
3. How you will calculate compliance with the MCLs, MRDLs and treatment technique.

The Stage 1 D/DBPR is a complicated regulation. Complying with it will be a major challenge for many of Missouri's public water systems. By the time this article is published, separate informational packets will have been sent to each system. If you did not get one of those or have any further questions contact the Public Drinking Water Program at (573) 751-5331.

Safe Drinking Water Hotline

(The following article is reprinted from the Safe Drinking Water Hotline's home page.)

The Safe Drinking Water Hotline provides the general public, regulators, medical and water professionals, academia and media, with information about drinking water and ground water programs authorized under the Safe Drinking Water Act. The hotline is operated under contract by Booz Allen Hamilton Inc., and housed in its Crystal City, Va., offices. The hotline responds to factual questions in the following program areas:

- ◆ Local drinking water quality
- ◆ Drinking water standards
- ◆ Public drinking water systems
- ◆ Source water protection

- ◆ Large capacity residential septic systems
- ◆ Commercial, and industrial septic systems
- ◆ Injection wells
- ◆ Drainage wells

"Water Lines" is the monthly hotline activity report that includes typical questions answered by the hotline, call/e-mail statistics, caller profiles and other water facts. Read current and previous issues of "Water Lines" online. (The Current Report, 2002 Annual Report, and Reports Archive are available.)

Contact the Safe Drinking Water Hotline for detailed information. Call toll free and speak with a specialist Monday through Friday, 9 a.m. to 5 p.m. eastern time (except federal holidays) at

1-800-426-4791 or 1-877-EPA-WATE. Local calls or international calls at (703) 412-3330.

Bilingual service is available. An introductory telephone message tells Spanish callers to leave a detailed message. Bilingual information specialists return these calls the same day.

The Safe Drinking Water Hotline telecommunications systems can receive recorded messages in English and Spanish 24-hours a day, seven days a week at 1-800-426-4791 or 1-877-EPA-WATE. Local or international calls can be made at (703) 412-3330.

Write to The Safe Drinking Water Hotline at 4606M, 1200 Pennsylvania Ave., N.W., Washington, D.C. 20460.

Comments? Questions? Contact us online.

By E-mail: hotline-sdwa@epa.gov.



Laboratory Holidays

The state health laboratory will be closed on the following state holidays:

Nov. 27-28, 2003, Thanksgiving Day
Dec. 25-26, 2003, Christmas Day



SDWC Acquires New Commissioners

Two new faces have joined the Safe Drinking Water Commission. Lanny Meng and Orville Schaefer have replaced Katie Wesselschmidt and Chet Dudley, respectively.

Meng is a farmer from Northwest Missouri. He is a graduate of the University of Missouri-Columbia with a bachelor's degree in agricultural engineering. He has been involved in a variety of state and regional issues related to agriculture and management of the Missouri River, and is active in local community affairs. Meng represents the public on the commission. His term expires Sept. 1, 2006.

Schaeffer is a businessman, farmer and water operator. He serves as the

certified water operator for several small public water systems in southeast Missouri. He has been involved in training water operators, residential and commercial water conditioning, and various local community activities. He represents public water systems serving less than 75 people on the commission. His term expires Sept. 1, 2006.

The Safe Drinking Water Commission is a nine-member board with responsibility to adopt rules for the administration, enforcement and implementation of the safe drinking water statutes, and to approve the intended use plan and priority point criteria for drinking water loans. The commission also provides insight and perspective to the Public

Drinking Water Program in many areas of the complex drinking water arena.

Four members of the commission must be associated with public water systems of various sizes and the other five members represent the water-consuming public. Commissioners serve without compensation, but are reimbursed for travel and other actual and necessary expenses incurred in the performance of their duties.

For more information about the commission, log on to <http://www.dnr.mo.gov/wpscd/pdwp/sdwcpdwp.htm> or call the Public Drinking Water Program at (573) 751-5331.

Explaining the Activated Sludge Process

It is to everyone's advantage for a community to be able to treat its wastewater in the most economical way. The activated sludge process has the advantage of producing a high quality effluent for a reasonable operating and maintenance costs.

The activated sludge process uses microorganisms to feed on organic contaminants in wastewater, producing a high-quality effluent. The basic principle behind all activated sludge processes is that as microorganisms grow, they form particles that clump together. These particles (floc) are allowed to settle to the bottom of the tank, leaving a relatively clear liquid free of organic material and suspended solids.

Described simply, screened wastewater is mixed with varying amounts of recycled liquid containing a high proportion

of organisms taken from a secondary clarifying tank, and it becomes a product called mixed liquor. This mixture is stirred and injected with large quantities of air, to provide oxygen and keep solids in suspension. After a period of time,

treatment. The resulting settled solids, the activated sludge, are returned to the first tank to begin the process again.

Initially developed in England in the early 1900s, the activated sludge process did not become widespread in the U.S. until the 1940s. Today a number of variations of the basic process have been developed. This issue of Pipeline includes descriptions of three of the most common variations: Extended aeration, sequencing batch reactors, and oxidation ditches. A glossary of terms can be found on page 5.

The activated sludge process is widely used by large cities and communities where large volumes of wastewater must be highly treated economically.

Activated sludge process plants are good choices too for isolated facilities, such as hospitals or hotels, cluster situations, subdivisions, and small communities.



Photo by Ed Winant, NSFC

Activated sludge package plant at Mason Dixon Elementary School in Monongalia County, West Virginia.

mixed liquor flows to a clarifier where it is allowed to settle. A portion of the bacteria is removed as it settles, and the partially cleaned water flows on for further

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Explaining the Activated Sludge Process

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The process

A basic activated sludge process consists of several interrelated components:

- An aeration tank where the biological reactions occur
- An aeration source that provides oxygen and mixing
- A tank, known as the clarifier, where the solids settle and are separated from treated wastewater
- A means of collecting the solids either to return them to the aeration tank, (return activated sludge [RAS]), or to remove them from the process (waste activated sludge [WAS]).

Aerobic bacteria thrive as they travel through the aeration tank. They multiply rapidly with sufficient food and oxygen. By the time the waste reaches the end of the tank (between four to eight hours), the bacteria has used most of the organic matter to produce new cells.

The organisms settle to the bottom of the clarifier tank, separating from the clearer water. This sludge is pumped back to the aeration tank where it is mixed with the incoming wastewater or removed from the system as excess, a

process called wasting. The relatively clear liquid above the sludge, the supernatant, is sent on for further treatment as required. See Figure 1 on page 6.

Sludge characteristics

By analyzing the different characteristics of the activated sludge or the sludge quality, plant operators are able to monitor how effective the treatment plant's process is. Efficient operation is ensured by keeping accurate, up-to-date records; routinely evaluating operating and laboratory data; and troubleshooting, to solve problems before they become serious. A wide range of laboratory and visual and physical test methods are recommended. Principally, these include floc and settleability performance using a jar test, microscopic identification of the predominant types of bacteria, and analysis of various chemical parameters.

The treatment environment directly affects microorganisms. Changes in food, dissolved oxygen, temperature, pH, total dissolved solids, sludge age, presence of toxins, and other factors create a dynamic environment for the treatment organisms. The operator can

Safety Considerations

- ✓ Practice careful personal cleanliness
- ✓ Require hard hats, boots and gloves
- ✓ Ventilate all covered tanks
- ✓ Prohibit smoking around the plant
- ✓ Consider empty tanks as enclosed spaces and apply the proper entry procedures
- ✓ Keep all hatches closed and secured
- ✓ Keep tank areas well lighted
- ✓ Keep walkways clear to prevent falling
- ✓ Provide lockout protection for all electrical equipment, gates or valves when in empty tanks

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Glossary

Activated sludge – sludge particles produced in wastewater by the growth of organisms in aeration tanks. The term 'activated' comes from the fact that the particles teem with bacteria, fungi and protozoa. Activated sludge is different from primary sludge in that the sludge particles contain many living organisms that can feed on the incoming wastewater.

Activated sludge process – a biological wastewater treatment process which speeds up waste decomposition. Activated sludge is added to wastewater, and the mixture is aerated and agi-

tated. After a certain amount of time, the activated sludge is allowed to settle out by sedimentation and is disposed of (wasted) or reused (returned to the aeration tank).

Aerobic – a condition where oxygen is present.

BOD – biological oxygen demand. Measure of oxygen organic material in the water requires.

Bulking – sludge that forms clouds in the secondary clarifiers when the sludge does not settle properly, usually caused by filamentous bacteria.

F:M – food to microbe ratio.

Floc – clumps of bacteria.

Flocculation – agitating wastewater to induce the small, suspended particles to bunch together into heavier particles (floc) and settle out.

Loading – a quantity of material added to the process at one time.

MLSS – mixed-liquor suspended solids.

MLVSS – volatile mixed-liquor suspended solids.

Mixed liquor – activated sludge mixed with raw wastewater.

Packaged plant – pre-manufactured

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Explaining the Activated Sludge Process

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change the environment (the process) to encourage or discourage the growth of specific microorganisms. See the Problem and Effect table.

Food (organic loading) regulates microorganism numbers, diversity, and species unless other factors limit it. It is important to maintain the proper ratio of food to microorganisms (F:M) to ensure optimum operation.

Activated sludge consists of a mixed community of microorganisms, approximately 95 percent bacteria and 5 percent higher organisms (protozoa, rotifers, and higher forms of invertebrates). Particular ones are considered indicator microorganisms that can be observed using inexpensive microscopes. Significant numbers of a particular species can indicate the condition of the process.

The most predominant microorganisms are aerobic bacteria, but there are also substantial populations of fungi and protozoa. Rotifers and nematodes are most frequently found in systems with long aeration periods.

Amoeboid forms, the flagellates, and the ciliates are the most common protozoans in a working sludge. Amoeboids predominate in 'young' sludges, such as at plant start-up or after an upset, such

as a shock load (when a stronger than usual batch of influent comes into the plant). Typically, little or no sludge forms at this time.

Flagellates are free-swimmers and predominate in light mixed liquors during high food to microorganism conditions. Their presence usually indicates poor effluent quality.

Free-swimming ciliates predominate as the F:M ratio decreases. Stalked ciliates predominate when there is an abundance of bacteria. Effluent and sludge quality are typically best when these types of microorganisms predominate.

Filamentous bacteria can cause the sludge not to settle properly, a condition called bulking, which causes clouds of billowing sludge rather than settling. These bacteria flourish when the excess sludge is not removed at the proper rate. Filamentous sludge bulking is a common problem at small, extended aeration treatment plants.

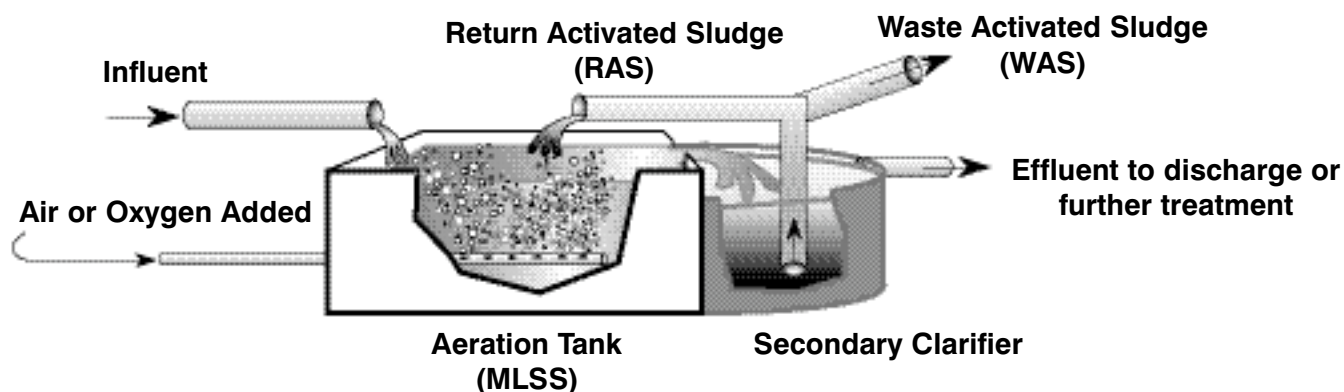
Problem / Effect

Problem	Effect/observation
Poor primary clarification	Plugging Standing water Odors Reduced efficiency
Hydraulic overload	High effluent TSS
Nitrification	High effluent TSS High chlorine demand Low pH
Nutrient shortage	Filamentous bacteria Rising sludge Pass through of soluble BOD
Organic overload	Pass through of soluble BOD Odors Low DO Poor effluent quality
Cold weather	Loss in removal efficiency Icing problems
Organic underload	High energy use Nitrification

Developing and maintaining good floc structure is critical for optimum system performance. A multiple jar test is a procedure used to evaluate the effectiveness of coagulants, optimum dosage for coagulation, concentration of the coagu-

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Figure 1 Typical Activated Sludge Process



Explaining the Activated Sludge Process

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lant aid and the most effective order in which to add various chemicals. It consists of a multiple stirring apparatus with a variable-speed drive. Samples are held in one- or two-liter jars or beakers.

The activated sludge samples are mixed and agitated for varying lengths of time, and then allowed to settle. The nature and settling characteristics of the floc are noted, as well as the clarity of the supernatant.

Chemical testing reveals sludge conditions and can warn of impending process problems. Compliance with the plant's National Pollutant Discharge

Glossary (... continued from Page 5)

treatment facility small communities or individual properties use to treat wastewater.

SRT – solids retention time.

Sludge – the solids that settle out during the process.

Supernatant – the liquid that is

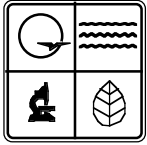
removed from settled sludge. It commonly refers to the liquid between the sludge on the bottom and the scum on the surface.

TSS – total suspended solids.

Wasting – removing excess microorganisms from the system.

Elimination System (NPDES) permit requires specific chemical analyses. Alkalinity, solids (total, suspended and dissolved), biological oxygen demand, chemical oxygen demand, nitrogen and phosphorus are some of the parameters that plant operators must monitor.

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